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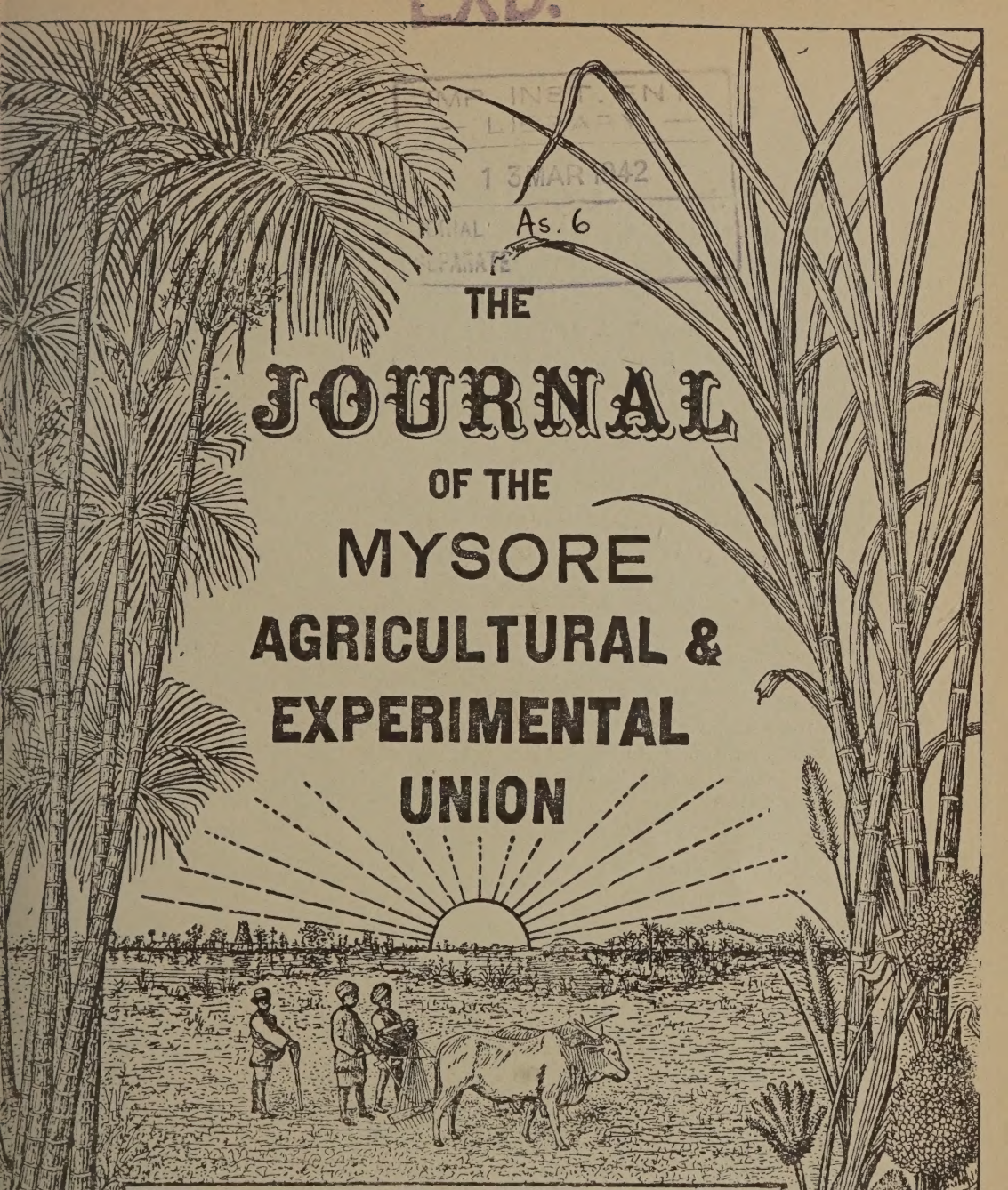

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Application of Modern Statistical Methods for Improving the Yield and Quality of the Agricultural Produce of the Mysore State.

THE JOURNAL OF THE MYSORE AGRICULTURAL AND EXPERIMENTAL UNION

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Paddy Cultivation in Mysore and How to Improve It

By
S. V. Sharma
Paddy Special Officer, Bangalore

At present there are about seven and a half lakhs of acres under paddy in the Mysore State. This constitutes about 68 per cent. of the whole area under irrigation from various water sources. With the completion of the Irwin Canal Systems, Marconahalli, Bhadra, Shimsha, Hemavathi, Lakshmanathirtha, Kapini and other projects, it is possible that another two and a half lakhs of acres may come under paddy. The average yield of paddy per acre for the State is about 5.7 pallas. At a moderate estimate, about 43 lakhs of pallas of paddy is produced every year. In addition to the above production, rice to the value of about a crore of rupees (16¼ lakhs of pallas in terms of paddy) is being imported into the State every year. Considering the average production of paddy in other countries, the State average of 5.7 pallas per acre is very poor. If our State is to be self-maintaining with regards to its requirements of rice, we have to increase the average production to at least nine pallas per acre, and it is possible to attain this level by:—

1. Maintenance of existing source of irrigation in perfect condition and economic use of water;
2. Effecting improvements in cultural methods;
3. Liberal and judicious manuring;
4. Seed selection and reduction of seed rate; and
5. Use of improved strains of paddy evolved on the various paddy-breeding stations.

1. It is a known fact that many of the tanks in the State have become silted up and consequently their capacity is much reduced. Some of the fields under every tank remain fallow. If these tanks are deepened and silt cleared periodically, more water can be impounded and successful crops harvested. This is one of the primary duties of a raiyat, which he has neglected of late. In these days of precarious rainfall, one need not stress the value of irrigation water for raising a crop. Our raiyats have got a mistaken notion that paddy cannot be grown successfully unless water constantly flows on the fields. Seeing that very good crops are being grown in Madhugiri, Challakere, and other taluks under well irrigation and also when we see that Trichy and Tanjore are receiving only intermittent water supplies, the idea of the Mysore raiyat has no basis. So, water should be economised as much as possible and made use of for cropping the fallowed fields also.

2. There are different methods of raising paddy crops in the State, *viz.*, (*a*) *punaji* or dry sowing method, as adopted in Bangalore and Kolar districts of the *maidan* area and the semi-*malnad* portions of Shimoga and Kadur; (*b*) sprouted seed sowing, or *mole* (ಮೊಳೆ) cultivation, as practised under some tanks for summer crops and also in some portions of the *malnad*; and (*c*) transplanting method as adopted by the raiyats in the channel area.

Though the various methods are adapted to suit the environmental conditions, it has been found that transplanting method is on the whole economical, resulting in better yield. So, whenever possible, it is advisable to adopt this in preference to others. In the case of dry sowing, sowing in drills is preferable to sowing seed broadcast. Less quantity

of seed is required for drill sowing, and as the seeds are in rows, better interculturing is possible.

3. As in the case of other crops, paddy also responds to heavy, but judicious manuring. It need not be said that well-preserved cattle-manure is the best for paddy, provided it is available in large quantities. With the lack of sufficient grazing land, and consequent scarcity of cattle in paddy areas, it has been a problem for a wet land cultivator to obtain enough manure for his paddy crop. Non-availability of firewood and consequent utilization of cowdung as fuel, increase the difficulty of manure supply. So, one has perforce to seek for other means of enriching the soil. Green-leaf manuring, wherever green leaves such as of *Honge,* Cassia, Yekka, *Ugani,* etc., are available, is one way of enriching the soil. In parts of Tumkur and Kolar districts one can see cartloads of these leaves being carted over a distance of even fifteen to twenty miles. Growing green manure crops on the fields, and ploughing them in before a paddy crop, is another form of enriching the soil with nitrogenous organic manures. Any quick-growing plant with good foliage can be grown and ploughed in. But, leguminous plants, by virtue of their having nitrogenous nodules in their roots are preferable inasmuch as they are capable of absorbing the atmospheric nitrogen and fixing it in the soil with the help of the bacteria in the nodules. Sunhemp gives large quantity of green matter per acre, say, from 6,000 to 10,000 lb. But, if it is not sown well within the season, it is likely to be infested with sunhemp caterpillar. Next to sunhemp, cowpea, especially the runner type, is the most advantageous. The raiyats in the channel area are in the habit of harvesting a pulse crop before paddy. Though this crop may bring in some money to the raiyat for meeting his transplantation expenses, it is not advisable to take a crop like this, as it will affect the yield of the paddy crop. The best thing will be to grow the green manure crop and plough it in when the plants are just in flowers.

Compost is another source of manure. Any organic refuse, both of animal and vegetable origin, can be composted

and converted into a valuable manure with appreciably good amount of nitrogen in a reasonably short period. If well prepared, this manure will be richer than even cattle manure. In addition to the various manures advocated above, a judicious application of artificial manures will decidedly increase the yield of paddy. It has been found by experiment, that a mixture of 80 lb. of ammonium sulphate and 80 lb. of concentrated superphosphate (or 168 lb. of ordinary superphosphate) per acre costing about rupees ten, is economical. Plots should receive a basic dose of at least one to two cartloads of organic manure for realising the full effects of artificials applied.

4. The raiyats do not generally pay much attention for selecting their own paddy seed. The paddy crop is harvested just when the crop is ripe but still moist. The harvested sheaves are left in the fields for a day or two, then bundled and threshed. The threshed grains are not well dried before storing, but are heaped up in the threshing floor for a few days before transport. During this heaping process, some heat is produced, and a sort of mild fermentation or curing takes place. Though this curing hardens the rice, and makes it less liable to break while milling, the viability of seeds is affected to some extent, and consequently, more seed is required per acre to get a good stand. The seeds intended for sowing should be allowed to ripen fully and well drained in the sun. Any mixture and weed seeds should be removed in the fields alone. The harvested seeds should be well cleaned and stored carefully. If seeds selected this way are obtained, anything from 15 to 20 seers will be enough for sowing an acre. The present seed rate as adopted by the raiyats varies from 30 to 80 seers or even 100. By careful selection and preservation of seed as mentioned above, it is possible to reduce the seed by at least 20 to 25 seers on an average. This means a saving of about two lakhs of pallas, which is not a small quantity to be neglected.

5. Other conditions being similar, the strains evolved on the various paddy breeding stations do give decidedly better yield than the local seeds of the same variety.

The total yields of the Nagenhally Paddy Breeding Station for the various years from 1928–29 to 1937–38 indicate that the yield has steadily increased from eleven pallas per acre, to nearly fifteen pallas per acre, mainly due to the increased yields of the various strains evolved there. Some of the main strains evolved on the Station, and advocated to the raiyats are mentioned below:—

Rainy Season Paddies

S. 67, Kembuthi.—This is a selection from local *Sanna Kembuthi,* a red-glumed and red-grained strain, giving a yield of 14 to 16 pallas of grain. This plant grows to a height of 4–5 feet. The straw is thick and hollow, slightly yellowish in colour. Straw being somewhat pliable, the plants are liable to lodge. The grain is dark reddish-brown in colour and awnless, but slightly tipped, medium coarse and full. Rice is dull-white in colour and rather sweet. The percentage of rice to paddy is about 50 by volume. Harvesting should be done in time to avoid breakage of rice while milling. This strain has given significantly better yields than the local variety tried alongside. Generally this is grown in Nanjangud, Krishnarajanagar, Heggadadevanakote, Holenarasipur and Arakalgud taluks where the raiyats prefer a paddy with a good amount of straw for cattle. This strain is known as December *Kembuthi* or Farm *Kembuthi* in some places. This is spreading slowly in the *malnads* also.

Planting season: July–August. Duration from planting: 5 months. Average yield per acre: (*a*) grain—14–16 pallas and (*b*) straw—6,000–7,000 lb.

S. 139, Kaddi.—This is a selection from Mysore *Kaddi* suitable for the same areas as S. 67; does well on soils of less than average fertility. It grows to a height of 5–5½ feet. The straw is thick and hollow and thicker than that of S. 67. Leaf-blades are long and broad. Plants lodge owing to heaviness of earheads, but the grains do not shed under ordinary conditions. Grain is awnless, straw coloured with slight brown spots, coarse and nearly 1½ times as big as

S. 67 and full. Rice is white and the percentage of rice to paddy is 50. This strain has been reported to be giving over 20 pallas per acre in Heggadadevanakote taluk. It is locally known as Select *Kaddi* or Farm *Kaddi* in some localities.

Planting season: July-August. Duration from planting: 5 to 5½ months. Average yield per acre: (*a*) grain—14–16 pallas and (*b*) straw—5,000–6,000 lb.

S. 476, Pattasamanhally Sanna.—This is a selection from *Pattasamanhally Sanna,* also known as *Kempu Sanna.* It is better suited for poor soils and newly formed fields. On fertile soils a large quantity of straw is produced at the expense of grain. Plants grow to a height of 4½–6 feet. Straw is pale yellow when green. Grain is brown coloured, medium, fairly full, rather plumpy and has a tendency to awn. Rice is white and takes fairly good polish. The percentage of rice to paddy is 48. The crop matures at about the same time as S. 139.

Planting season: July–August. Duration from planting: 5–5½ months. Average yield per acre: (*a*) grain—12–14 pallas and (*b*) straw—4,500–5,500 lb.

S. 236 and S. 246, Nagapuri Sanna.—These are strains from *Nagpur Sanna* or *Muthina Sanna* as locally called. Plants grow to about 3½–4½ feet and are fairly good tillerers. Owing to weak straw the plants lodge even at the milk stage. The grains are liable to shed if not harvested just when ripe. They are very fine, slender, proportionately long and slightly curved with a tendency to awn and not quite full. Rice pearly white, takes good polish, fetches good price. Percentage of rice to paddy is 46. These strains are largely grown in Seringapatam and French-Rocks taluks for the past 5–6 years and are well reported on. They have also been tried in the various places in the State including the *malnad.* Though these selections are very much liked in the *malnad,* their lodging and shedding habit stand in their way of extending in the locality. The difference between S. 236 and S. 246 is that the grain of the former is

slightly yellowish and that of the latter straw-coloured and more attractive.

Planting season: July–August. Duration from planting: 4–4½ months. Average yield per acre: (*a*) grain—15–18 pallas and (*b*) straw—4,000 lb.

S. 590, Sakalathi.—This is a plant selection from *Sakalathi* or *Haladi Sanna.* Growth and habit of the plant are similar to those of S. 476 but the grains are finer, slenderer and longer, but not quite full. The glooms are yellowish-brown in colour. Rice is pearly white in colour. The percentage of rice to paddy is 47. This matures 15 days earlier than S. 476.

Planting season: July–August. Duration from planting; 4½–5 months. Average yield per acre: (*a*) grain—12–14 pallas and (*b*) straw—4,000–5,000 lb.

S. 54.—It is a selection from *Nattanhalli Sanna* and is a fine variety like S. 246, giving an average yield of 12 to 14 pallas of grain per acre. Unlike S. 246, this strain does not generally lodge. It is largely being grown in Seringapatam and Krishnarajanagara taluks.

S. 624 and S. 625.—These are selections from *Maharajabhoga,* a variety with clustered earheads, giving significantly higher yields than G.E.B. 24. On account of the drooping habit of the earheads and the clustered nature, the percentage of chaff in these two strains is perceptibly more than in other varieties. The average yield is about 15 pallas per acre.

S. 661, G.E.B. 24 or Coimbatore Sanna (as locally called).—This is a mutant isolated from G.E.B. 24 (a strain evolved on the Paddy Breeding Station, Coimbatore). This strain is similar to G.E.B. 24 in habit and grain formation, but the grains are slightly coarser. It has given significantly better yields than the mother variety. Grain is straw-coloured and fine. Colour of rice is white. Percentage of rice to paddy is about 52. This strain has been tried in several places in the State, especially in the *malnads,* both by broadcast and transplanting methods. With the exception of a few places, it has given uniformly higher yields

than the local variety tried alongside. This strain being decidedly finer than many of the *malnad* varieties, fetches a high price with the result it has found favour with the *malnad* raiyat.

Planting season: July–August. Duration from planting 4–4½ months. Average yield per acre: (*a*) grain—above 16 pallas and (*b*) straw—3,500–4,000 lb.

S. 683 and S. 684, G.E.B. 24 or Coimbatore Sanna.—These are also mutants from G.E.B. 24. Grains of the former are slightly shorter and stouter than those of the latter; but both are fine strains. They were tried in several places in the channel area of Mysore and Hassan districts and also in tank-fed area of Bangalore district. They have invariably given better yields than the local varieties with a difference of about 2–3 pallas per acre. In fact these are the two main strains that are under distribution in the channel areas of the Mysore district.

Planting season: July–August. Duration from planting: 4–4½ months. Average yield per acre: (*a*) grain—14½–15 pallas and (*b*) straw—3,500 lb.

S. 701, G.E.B. 24 or Coimbatore Sanna.—This is a mutant with a very fine grain yielding pearly white rice. The growth of the plant is rather stunted when compared with G.E.B. 24 and the yield of straw is poor. The grain is straw-coloured, fine, awnless and full. Rice looks very much like that of S. 246 but not curved. Percentage of rice to paddy is about 52. This strain goes by the name of *Brahmasale* in the Mysore market.

Planting season: July–August. Duration from planting: 4–4½ months. Average yield per acre: (*a*) grain—12–14 pallas and (*b*) straw—2,750–3,000 lb.

S. 699, G.E.B. 24 or Coimbatore Sanna.—This is a coarse-grained mutant, giving on an average 15–16 pallas of grain per acre. This may be grown wherever a medium coarse variety like Co. 1 of the Coimbatore Paddy Breeding Station, is generally grown. It matures one weak to a fortnight earlier than the latter. Though this strain lodges when grown on rich soils, there is no fear of the grains

shedding much. Rice is pearly white and long and the percentage of rice to paddy is 52.

Planting season: July–August. Duration from planting: 4–4½ months. Average yield per acre: (*a*) grain—15–16 pallas and (*b*) straw—3,000–3,400 lb.

S. 269, Ghanasale.—Those who require a selection that is non-shedding under ordinary conditions, even if the crop is allowed to remain on the fields for a few days more than necessary, are recommended to try this strain from *Ghanasale*. It gives a fairly good yield of 13–15 pallas. Being a poor tillerer, close planting should be adopted to obtain good results. The grains do not fall off easily while threshing. In fact it requires more men to thresh it clean than in the case of other paddies. It is advantageous to stack the sheaves for a month or two before threshing, as this will enable the grain to fall off easily. The grain which is straw-coloured is slightly coarse when compared with G.E.B. 24 and has a tendency to awn. Rice is white and the percentage of rice to paddy is 50. This strain seems to have a good future in the *malnads*.

Planting season: July–August. Duration from planting: 4–4½ months. Average yield per acre: (*a*) grain—13–15 pallas and (*b*) straw—3,500–4,000 lb.

S. 197 and S. 199, Alur Sanna (fine).—These are selections from *Alur fine*, maturing in 4 months after transplanting. These are recommended for tank-fed areas and also for channel areas infested with wild paddy. These strains mature much earlier than the wild paddy and as such the undesirable contamination from the weed seeds is avoided. These two strains have been found to do well even in the *malnads*, where on account of their early maturity a good crop is assured even if late rains fail. Plants grow to a height of about 4½ feet and lodge. But the grains may not ordinarily shed. The grain is straw-coloured, medium long, tipped and fairly full. Rice is white and the percentage of rice to paddy is 48. The yield is as much as that of G.E.B. 24 tried alongside. These strains are not suitable for summer conditions.

Planting season: July–August. Duration from planting: 4 months. Average yield per acre: (*a*) grain—14–16 pallas and (*b*) straw—4,000–4,500 lb.

S. 705, Bangar Kaddi.—This has been tried in various places during the summers of 1937–38 and 1938–39 in the raiyats' fields and throughout its performance has been very encouraging. It is an all-season variety, but gives higher yield under summer conditions. On an average it yields from 18–22 pallas per acre as a summer crop, but it has been reported to have given yields of over 30 pallas in some villages in Madhugiri and Tumkur taluks. Its yield during the rainy season obtained on the Paddy Breeding Station was 11–13½ pallas. The plant grows to about 3½ feet in height and it does not ordinarily lodge. Paddy is brown-coloured and medium-sized, very much like that of S. 476. Rice is dull white and flinty. The percentage of rice to paddy is 52. The crop matures in 3 months after transplantation.

Planting season: All seasons. Duration from planting: 3 months. Average yield of straw: about 4,000 lb.

S. 396, Yelandur Sanna.—This is a selection from *Yelandur Sanna* suitable for all seasons as in the case of S. 705. The yield varies from 10–12 pallas. Plants are dwarfy in stature and non-lodging. Grains are straw-coloured and very coarse. Rice is dull-white and the percentage of rice to paddy is 52.5. The crop matures in 3 months from the date of planting.

Planting season: All seasons. Average yield of straw per acre: 3,000 lb.

S. 317, Halubbalu.—It is a selection from *Halubbalu* giving 2–3 pallas more than the local *kar* paddy. It may be grown as a rainy season crop also, but the yields are generally poor. Grain is medium-sized and straw-coloured. Rice is dull white and the percentage of rice to paddy is 52.

Planting season: Summer. Duration of crop from planting: 3½–4 months. Average yield per acre: (*a*) grain —12–14 pallas and (*b*) straw—4,000 lb.

S. 547, Chintamani Sanna.—This strain matures in 3½ months from the date of transplantation. This is suitable mainly for summer. In good soils it grows to a height of 4½–5 feet. It has been tried in many places in the Tumkur district. It is reported to have given 32 pallas per acre against 20 of the local variety in some places. The general yield varies from 13–22½ pallas according to the soil; yields good quantities of straw also. The grain is medium, fine and long. Glumes are deeply furrowed, rather thick and light brownish-yellow in colour. The rice is light brown in colour and the percentage of rice to paddy is 45.

Planting season: Summer. Duration of crop from planting: 3½ months. Average yield per acre of (*a*) grain —13–15 pallas and (*b*) straw—4,500–5,500 lb.

S. 328.—This is a selection from *Banku,* a slender and very long grained type; suitable for late rainy season; gives a good yield of straw and grain. An yield of about 15–16 pallas is reported from the districts; matures in about 3½ months from planting; does not generally lodge. Plants do not generally flower in summer.

The strains suitable for *malnad* conditions have been evolved on the Marthur Farm. Some of these are, AS. 1129, VH. 2429, D. 529, D. 1329, D. 629, W. 3929, W. 529, HO. 829, SI. 1329, etc.

In conclusion, if the various projects are completed, and if the methods advocated in this note are followed, it is quite possible to double the production in a reasonably short time as indicated below:—

	Pallas
Average annual production varying round about at present	42,50,000
Increase of yield due to increase in area	15,00,000
Increased capacity of tanks properly maintained 10% (60,000 acres)	3,60,000
Savings due to reduction of seed rate at 20 seers per acre—1,000,000 acres	2,00,000
Increase due to artificial manures at $1^1/_2$ pallas per acre	15,00,000
Increase due to introduction of improved seeds at the rate of $1^1/_2$ pallas per acre	15,00,000
TOTAL ..	93,10,000

which works up to a State average of 9.3 pallas per acre.

Before closing the note, it may be mentioned that the admixture of small stones and weed seeds, especially of *Gantubhatta* and *Bhimanakaddi* in Mysore rice is mostly responsible for the latter not being sold readily in the Bangalore market.

Instructions given in the *Mysore Agricultural Calendar,* 1937, in this regard may be followed and the paddy kept free from these two avoidable blemishes. Anybody requiring further information on the subject may correspond with the Paddy Special Officer, Bangalore, or with the nearest Agricultural Officer.

Application of Modern Statistical Methods for Improving the Yield and Quality of the Agricultural Produce of the Mysore State

By

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The three grades of falsehoods according to an old gibe are, "Lies, Damned lies and Statistics". But it is now well known that statistics is nothing but commonsense developed to a high mathematical degree, employing the sound and established principles of logic. In recent years, modern statistical methods have become almost indispensable for investigations in Agriculture, Biology, Public Health, Psychology, Meteorology, Economics, Education, Industry, Medicine and Insurance.

Efficiency or superiority of any treatment or variety of a crop is judged from its average performance and the percentage of success attained. Forecasts of crops, weather, diseases, etc., are based on elaborate statistical calculations. Statistical enquiries are conducted by Governments, Institutions, Insurance Companies, Commercial and Industrial concerns in order to base their conclusions on facts and figures and not on suspicions and suppositions. Such is the part played by statistics in modern life and administration.

Compilation of facts and figures for proper administration of the State was probably the origin of the study of statistics. Now, there are two aspects of statistics, the descriptive and the analytical, which are complimentary to each other. The importance of statistics has now increased to such an extent that separate statistical departments are set up in practically all branches of Science by Governments for the compilation and study of facts and figures. Statistics, as most people imagine, is not merely a collection of a huge mass of figures on any particular subject and the

determination of the total or the average. This, for most purposes, is inadequate. The more useful, difficult and interesting portion is the study of the variation of the figures, the reduction of the huge mass of figures to a few understandable statistical constants and the proper expression of the conclusions. The importance and the necessity for the study of the analytical portion of statistics for purposes of practical utility, can be realised when it is remembered that in practice, complete enumeration is almost always impossible. Samples have to be taken from the population for study. That they have to be statistically estimated for information from such samples is naturally incomplete. Reliable estimates can only be obtained from a thorough statistical study of the samples.

In agriculture, necessity for the application of statistical methods increased when the inaccurate and unreliable methods of collecting the data and interpreting them became more and more obvious. These were studied intensively by Mathematicians, chief among them being Laplace, Gauss, Galton, Pearson, Yule, Fisher, Elderton and Yates. The subject has advanced to such an extent that it has now become the domain of a specialist, the Statistician. He studies the problem at hand, suggests proper and suitable methods of experimentation to collect data in such a way as to avoid disappointment and unnecessary waste of energy and money; he employs proper methods for a valid interpretation of the data and states the extent of reliability of the conclusions by applying suitable tests of significance.

Application of modern statistical methods to agricultural problems in India can be stated to be very recent. The Imperial Council of Agricultural Research and the Section of Agricultural Meteorology of the Government of India and the Indian Statistical Laboratory at Calcutta are the premier institutions which began an intensive study of this subject as applied to Indian conditions. The Mysore Agricultural Department introduced this subject only very recently, that is, in January 1939 and the experience gained on modern statistical methods at the above three institutions under

Dr. L. A. Ramdas, M.A., Ph.D., etc., Agricultural Meteorologist, Poona, Rao Bahadur Vaidyanathan, M.A., L.T., F.S.S., etc., Statistician to the Imperial Council of Agricultural Research, New Delhi, and Prof. P. C. Mahalanobis, M.A., B.SC., etc., Director of the Indian Statistical Laboratory, Calcutta, have been put into use. As a result of this, the Department has attained a very high standard, probably the highest standard of accuracy hitherto attained, regarding field experimentation. This can be seen from the large number of field experiments based on the most modern statistical methods, started since February 1939, on practically every crop and every aspect of agricultural problems. Thus agricultural research on the fields has now been re-organized by the Director of Agriculture, with a view to obtain more accurate results based on statistical methods and thus improve the yield and quality of agricultural produce of the State.

Introduction

Many workers even in these days of advanced scientific agricultural research are sceptical about the utility of statistical methods in agriculture and some even offer criticisms. This is entirely the outcome of the lack of knowledge on the elementary and fundamental principles of statistics. An attempt is made in this series to explain some of the fundamental principles of statistics, to indicate the necessity for statistical methods in agricultural research and to explain the methods now adopted by the Department to attain the very high accuracy in field experimentation.

Necessity for Experiments

It is not unusual to meet with persons who put the question, "Are experiments necessary?" We live in a world of doubts; doubts exist in every branch of Science. The problem of improvement of crops and farming methods is full of doubts. These doubts have somehow to be either disproved or confirmed. Experiments, according to the definition of Webster, are meant to confirm or disprove doubts.

At first sight, it might appear very easy to conduct experiments and solve problems in agriculture. In fact, the belief in the simplicity of experimentation was the greatest obstacle for its progress. It will be seen how easy it is to obtain unreliable and wrong conclusions by adopting defective technique in designing the experiments and by wrongly interpreting the data or by both.

Necessity for Field Experiments

Investigators in the laboratory and with pot culture are in a much happier position in that they can deal with single factors keeping other factors constant. But their results do not always agree with those obtained from experiments on the field. Hand-in-hand with experiments in the laboratory and pot culture, experiments on the field, have to be conducted to confirm the results obtained and thus arrive at the most reliable and useful results. The final test of all experiments should therefore always be made in the field. The place of field experiments in agricultural research has been assured since many years, for the above reasons.

Difficulties Met With in Field Experiments and Methods of Overcoming Them

Experiments on the field are much more complicated than what they appear to be, due to various disturbing factors such as differences in soil, climate, etc. Agricultural research, unlike research in most other branches of science, is at a disadvantage, for experiments have to be conducted under unavoidable conditions in the field which are imposed on the worker by nature. Sir John Russell, of the Rothamstead Experiment Station, says in a note on the application of science in agriculture, "Field experiments, simple as they appear to non-experts, rarely give clear-cut results. With only single plots, a result may seem to emerge but the results are confusing if plots are replicated." But replication of plots is one of the fundamental principles of statistics. "Data of field experiments are unintelligible due to irregularities in the seed, the soil and watering, the cultivation, the

incidence of the diseases and pests. Of these, irregularities in the seed can be minimised by the use of a pure line; cultivation of experimental plots may be made uniform," ....., "while the incidence of diseases, if it cannot be regulated, can at least be recorded. There remain the irregularities of soil and water distribution, which may escape not only control but even recognition. Statistical methods can cast out their effects; the methods are not easily reduced to rule and in the hands of inexpert people may prove treacherous but they can easily be applied by any mathematically trained person who knows statistical theory."

Necessity for Statistical Methods in Agriculture

Curiously enough, even in these days of advanced scientific agricultural research, some experimentors argue that their results are so obvious that they do not need statistical methods. But examples in published papers can be shown where the conclusions drawn have little foundation in the data. Experiments, often have been designed defectively, with the result that the whole experiment is a wasted effort. Often, the Statistician is asked to make "the best of a bad job" by being asked to analyse the results of an experiment designed with no consideration to the fundamental principles of statistics.

Single-plot Experiments

Again, some people doubt the utility of statistical methods and argue that experiments in agriculture were conducted in those early days when statistics was unknown. But it should be remembered that agricultural problems were very simple in those days. There were only a few varieties, few manures and probably very few cultural methods at the choice of the worker to experiment with. Only broad questions such as the comparison of manuring and no manuring had to be answered. Single-plot experiments were very common. Take the simple case of comparison of two manures. Two plots of identical shape and size would be selected and treated alike in all other respects except those to be compared. Any difference in the yield would be attri-

buted entirely to the treatments. The world famous manuring experiment on Broadbalk-Field at Rothamstead which has given the main principles of manuring is a single-plot experiment. It was started in 1843 and is still continuing. This began with a 10% difference and has now increased to 100% between the two plots. It will be seen that single-plot experiments can give reliable results only if large differences between the two treatments are expected and if the problems are simple. But if large differences are not expected as it happens now, between the several treatments and if the problems are complicated, then such single-plot experiments are the most deceptive and become unreliable.

Objects of Statistical Methods in Agriculture

Conditions are now very much altered. The raiyat is hard-hit and even a few seers more per acre is a handsome gift and a boon to him. A very large number of varieties or strains, manures or fertilizers and methods of cultivation are being evolved and found by the Mysore Agricultural Department with the object of selecting and giving to the raiyat a variety, a manure and a cultural method, superior to those he is using and thus improve his lot. Reliable field experiments are necessary to select the best variety, the best manure and the most suitable method of cultivation. Special statistical technique to suitably design experiments for testing these large number of varieties, manures and the cultural methods and special statistical methods to interpret the data of these complicated experiments properly have been found to be absolutely and fundamentally necessary to obtain valid and reliable conclusions. Therefore, the technique of field experimentation has become very complicated.

Some Common Defects in Field Experimentation

Some of the statistical methods like the Randomized Blocks, Latin Square, Split-plot Designs worked out by Fisher for field experiments are familiar to most of the workers. These are no doubt very efficient and simple methods to obtain valid and reliable results. But much pre-

liminary investigation and great care is necessary in using them, to avoid disappointment by getting no result even after working for many years. There are many instances where even with such methods, satisfactory results have not been obtained, due to reasons such as lack of sufficient number of replications, using an improper size and shape of plot or using an unsuitable lay-out. A manurial trial, say, on two varieties is conducted best with a split-plot design but the distribution of the varieties and treatments may be such that the experiment becomes more efficient to compare the varieties rather than to compare the treatments. Often, some experiments will have to be conducted over a sufficient number of years to allow for a reasonable weather sampling. Experiments on perennial crops like coffee, cardamom, coconuts, etc., have not been very successful due to reasons such as lack of knowledge on the fundamentals of their technique. Special methods are necessary for successful experimentation with perennial crops. Residual and accumulated effects of manurial treatments for any crop have to be studied by proper technique. Experiments on rotation of crops have to be studied with special lay-outs. Border effects in field experiments have to be studied. Suitable sampling methods have to be evolved for our conditions. Thus much preliminary investigation and great care would be necessary to design experiments and interpret the results.

One other aspect of great agricultural importance hitherto overlooked to a great degree by agricultural workers has now been successfully investigated by Fisher and Yates. The time-honoured classical procedure has been for Botanists to conduct varietal trials to find the best variety, for Chemists to conduct manurial trials to investigate the manurial requirements and others to conduct cultural trials to determine the most suitable method of cultivation, rate of sowing, etc. Thus each worker has been confining himself to experiments on single factors. More often, it would happen that manurial trials were conducted on a variety which would fail to come out successful in a varietal trial or *vice versa*. It is possible that conclusions laboriously arrived at on the manurial

requirements for one variety may not apply to the variety finally chosen. Varietal differences are not always the same for all levels of manuring and all cultural practices. Responses to manures often change with change in cultural practices. Interactions between varieties, manures, cultural methods, seasons and places, which are now known to be of great agricultural importance could not be studied by such separate trials.

Recent Advances in Field Experimentation

Complex and Factorial Experiments.—Fisher and Yates studied these problems and have found out methods to survey the whole field and the interactions, instead of confining to experiments on single factors. "It is the glory of the recent developments of statistics," says Rao Bahadur Vaidyanathan of the Imperial Council, "that modern field technique aims at testing any number of interrelated factors simultaneously". Factorial experiments (orthogonal and non-orthogonal) include all combinations of several different sets of treatments or factors and give information on interactions. These are not possible from experimental designs of the usual types such as Randomized Blocks or Latin Squares on single factors. Moreover, complex experiments economise time, space and energy. Certain agricultural difficulties met with in practice such as lack of sufficient land of convenient size and shape, lateral seepage of water from plot to plot in irrigation experiments, etc., to conduct complex experiments have been overcome by Fisher and Yates by methods of confounding deliberately some effects. Factorial experiments are very complicated to design and to interpret.

A number of factorial experiments, both orthogonal and non-orthogonal, on practically every crop and every aspect of agricultural problems have been started in the several farms of the Department.

Take the case of one of the experiments on sugarcane, laid out on the Irwin Canal Farm, Mandya, and the Babbur Farm, Hiriyur, in which three varieties of sugarcane are being tested to determine their responses and interactions to

the three manures, nitrogen, phosphoric acid and potash, each one of them at three different levels. Ordinarily, perhaps five separate experiments would have been conducted, first to try the three varieties of cane, second to try the three levels of nitrogen, third to try the three levels of phosphoric acid, fourth to try the three levels of potash and the last to try the three manures. These five separate experiments would not only increase the energy, space and time but also they would fail to yield the important and useful information that would now be given by the single complex ($3 \times 3 \times 3 \times 3$ factorial experiment) trial of 81 combinations. Methods of confounding have made it possible to have only nine instead of eighty-one plots in each block and to have only two replications.

Again another recent development in the technique of field experimentation is with regard to varietal trials. Plant breeders have been evolving hundreds of new strains and so far, large number of varieties of a crop could never be satisfactorily tested in a single trial. The time-honoured classical methods of row tests and strip-methods have become obsolete due to their inefficiency. Even the usual statistical lay-outs such as Randomized Block or the Latin Square have been found to be inefficient for testing varieties in numbers higher than 15 or 16. Yates investigated this problem and has developed recently methods such as pseudo-factorial or quasi-factorial designs of two and three dimensions, incomplete block methods, etc., for testing any large number of varieties, very efficiently. Here again, methods of confounding have made it possible to keep the block size small and to increase the efficiency of comparisons to a very high degree. The statistical analyses of the data as well as the designing is very complicated, requiring great care. Rao Bahadur Vaidyanathan suggests three stages in such varietal trials of large numbers. In the first or the preliminary stage, all inferior ones are rejected and the best 15 or 16 are selected for further trial in the second or the secondary stage. Then the best four or five of these are selected for further trial in the final stage.

For the first time in the history of the Department, a thorough investigation is being made of all the varieties in all important crops of the State on modern statistical lines on the several farms.

Take again, the case of field experimentation on perennial crops. These, as previously mentioned, have not been very successful due to defective lay-outs and lack of knowledge on the fundamentals of field technique for perennial crops. The Chief Scientific Officer of the Coffee Research Station, Kenya, says, "A field experiment with a heterogeneous crop is a complicated and precarious business calling for the utmost care and patience..... It is now universally recognised that certain data must be accumulated before precise field experiments can be successfully carried out." Recently, a thorough statistical examination of the data on some of the manurial and cultural experiments was made and preliminary investigation on the errors involved in field experiments with coffee was completed. On the basis of the results obtained and some suggestions of the Statistician to the Imperial Council, most of the field experiments on coffee have now been modified and started afresh on the Coffee Experimental Station at Balehonnur.

Programme of Statistical and Experimental Work

Experience has shown that it is never safe to introduce a new variety, a new manure or a new cultural method in any tract without a thorough and a satisfactory trial. Hence, careful planning and organisation in experimentation is necessary. For instance, in introducing a new variety, the following programme has been found to be very efficient, wherein three stages exist. In the first stage, experiments of the nature described in the previous paragraphs, are necessary in order to obtain reliable conclusions. They are complicated in nature requiring the services of not only a specialist—the Statistician—to design them and to interpret the results, but also trained labour, good supervision and much expenditure. Evidently, these are possible only on the Departmental Farms where such facilities are easily available. Then all material inferior to the local variety, manurial

and cultural methods are eliminated and the most promising ones are selected for further trial.

It has been found that varieties, manurial or cultural methods selected out of elaborate experiments on experimental farms, have at times failed in certain areas due to many disturbing factors. It is possible that a strain may do very well under the special conditions of the farm but fail to maintain its superiority over any considerable area outside. Hence the second stage in experimental work is found advisable and even necessary. The most promising varieties, say four or five selected out of the complicated experiments on the experimental farms, are further tested by conducting varietal trials extensively in as many localities as is necessary to secure a representative sample of the tract. For this, the co-operation of the more advanced raiyats becomes necessary. In the beginning there is a natural reluctance shown by the raiyats to spare land for such experiments, due mainly to the fear that they would lose their crop and get nothing from the experiment. Hence, greatest care is necessary while conducting such experiments on the raiyats' fields, to see that there is no undue strain exerted on his resources and further greatest caution is necessary to see that inferior varieties likely to disappoint him are rigorously excluded and the number of varieties are kept small. These trials depend on the goodwill of the cultivator and if retained, they possess the advantage of not only confirming the results obtained on the experimental farms but also the raiyat himself can observe differences between varieties growing under his own conditions and will have no hesitation in taking up the cultivation of the variety which has proved promising on his own land. Even here, trials need the application of statistical methods in order to obtain reliable information, particularly when the differences between the varieties are not big. Experimental methods of the simplest possible types have been devised by Statisticians for such trials. Independent trials may be conducted by each raiyat or the trial may be distributed among, say, 7 to 8 villages. Thus in this final stage the best

and the most suitable variety for particular tracts are selected, which are further tried in plots with only single replication in as many localities as possible. Such trials for purposes of demonstration are necessary. The article on the "Demonstration Plots in the Raiyats' Field," contributed by the Director of Agriculture in Mysore, to the *Mysore Agricultural Calendar of* 1939, gives the objects, the necessity and the utility of such demonstration plots.

From Our Co-operators

"The foremost problem of the Department is how to bridge the gulf between the Departmental Farm and the raiyats' holding and how to incorporate into the raiyats' cultural practices the improvements in Agriculture adopted in the Departmental Farms. It is therefore of the greatest importance that the economic advantages of the improved varieties of crops and improvements in manuring and cultural methods should be demonstrated in the raiyats' fields and with the labour and resources available to him from day to day," observes the Director of Agriculture in his article on "Demonstration Plots in Raiyats' Fields" in the Mysore Agricultural Calendar *for* 1939. *Further in the same article it has been stated that with a view to accelerating the adoption of improvements in agriculture by a widening circle of raiyats a scheme of systematically laying demonstration plots in raiyats' fields was sanctioned by Government in their Order dated* 31*st July* 1937.

The following are the opinions of a few co-operators who conducted the demonstrations in their holdings:—

Ragi

1. *K.* 1 *Ragi.—*

Mr. D. S. Ramiah, Shanbhog, Channarayapatna, Devanahally Taluk:—

"I sowed the K. 1 ragi seed given by the Department on a plot of 15 guntas. It yielded 720 seers of grain and 3 cartloads of straw. The local *gidda* ragi sown on a plot of similar area yielded 324 seers of grain and 2¼ cartloads of straw. The crop of K. 1 ragi was very good to see. It suffered a little from drought. In my opinion it is one of the best strains of ragi both for grain and straw."

2. *K.* 1 *and E.C.* 593 *ragis.—*

Mr. Pilliah, Ganval, Kasba Hobli, Kankanhally Taluk:

"The K. 1 ragi crop raised by me yielded 9 pallas of grain per acre. I raised seedlings of E.C. 593 ragi for demonstration and transplanted them on 10–9–1939. This crop matured a little late, but the earheads had longer spikelets. I obtained 3 pallas of grain from 12 guntas of land. This works out to 10 pallas of ragi per acre."

3. *E.S.* 11 *ragi.*—

Mr. Govindiah, Bajjanahalli Village, Kolal Hobli, Koratagere Taluk:—

"I raised E.S. 11 type of ragi in 22 guntas of my land. The crop grew well in spite of the fact that rains failed for a short while when the crop was growing. On harvesting the crop on 16–1–1939, I obtained 380 seers of ragi and 3,600 lb. of straw."

Groundnut

1. *Spanish Groundnut.*—

Mr. Siddapparadhya, Bachanahalli, Holenarasipur Taluk:—

"On growing the Spanish variety of groundnut supplied by the Department and the local groundnut side by side, on plots of similar area, the Spanish yielded 6 pallas, whereas the local yielded 4 pallas of pods, though under droughty conditions. In my opinion the Spanish variety is the better variety."

Mr. T. Nanjundiah, Bandenhally Village, Kasba Hobli, Channarayapatna Taluk:—

"I was given 50 seers of Spanish groundnut pods by the Department and I sowed the seeds on 20 guntas of land. The crop suffered a great deal for want of rain. Under these conditions the Spanish variety yielded 150 seers of pods whereas on a plot of similar area the local groundnut yielded 67 seers of pods. In an one-acre plot, half of which was manured with fertilizers and half unmanured, the fertilized half yielded 180 seers of pods and the unfertilized 120 seers."

Manurial Trials

1. *Sugarcane.*—

Mr. Chennappa, Chairman, Village Panchayat, Dodkadnur, Holenarasipur Taluk:—

"I arranged a test, manuring a 5-gunta plot of cane with fertilizers advocated by the Department side by side with a 5-gunta plot which was not so manured. From the fertilized plot, I obtained 24½ maunds of jaggery and 22 maunds from the unfertilized plot. Both plots suffered from the beginning for want of sufficient water."

Mr. Nanjundegowda, Cholenhally, Kasba Hobli, Channarayapatna Taluk:—

"I applied the fertilizers supplied by the Department to 5 guntas of sugarcane. The cane was all harvested by 30–8–1939. The jaggery obtained weighed 25¾ maunds. From 5 guntas of unmanured cane only 16 maunds of jaggery was obtained. This experiment indicates that fertilizers do increase profits from cane."

Cotton

Mr. M. C. Ramanathan, Adivala Farm, Hiriyur Taluk:—

"I sowed Cambodia and C.N. cotton seeds side by side, each over half an acre in land bearing survey number 18, in the Pathrahalli Village. The land was ploughed by the iron plough and was sheep-folded for manuring. When the crop was three months old a top dressing of cattle manure was given.

Six pickings were taken of the cotton crop. Cambodia yielded at the rate of 29½ maunds of cotton per acre and C.N. 24½ maunds kapas with seed.

In my experience C.N. cotton matures a month later than Cambodia. Both the varieties are free from disease."

Napier Grass

Mr. B. G. Sreedhar, Hinkal Village, Mysore District:—

"For the first time in this area, I grew Napier grass from seedlings supplied by the Department. Cattle eat this grass with relish. It tillers well and grows to a height of 4 to 5 feet. Seeing this, I have raised my own seedlings also and I have transplanted these in half an acre. It is coming up well. The straw being slender, the cattle eat it without any wastage."

Mr. R. Krishna Murthy, Mysore:—

"I have grown Napier grass in my fields this time as suggested by the Department. Every stool has 25 to 50 tillers, growing 5 to 6 feet high. Cattle eat this grass with relish. I intend to grow this on a larger scale next year."

Mr. K. Nagaraju, Padavarhally, Mysore Taluk:—

"I obtained a supply of seedlings from Jeevanrayanakatte Farm and planted them in my fields. The grass grew 4 to 5 feet high. Cattle are eating it with relish. The grass grows well even in dry lands and tillers sufficiently well to give a bumper harvest."

Government Orders Pertaining to Work on Raiyats' Fields

In the last issue of this *Journal* the copy of Government Order No. D. 8393–94|Agri. 178–38–4, dated, Bangalore, 28th March 1939, pertaining to the scheme of Subvention Farms was published. A subvention farm is meant for a comparative trial of new strains of crops intended for the locality. For the co-operation he extends to the Department, the party is paid a subvention up to Rs. 25 for dry crops, Rs. 50 for paddy and Rs. 100 for sugarcane, according to the latter Government Order No. A.F. 4057–8|Agri. 57–39–4, dated, Bangalore, the 7th Feb. 1940, in this regard.

Below are published copies of Government Orders pertaining to other schemes, *viz.*, the Demonstration plots and 'A' Farms for multiplication of pure seed.

Demonstration Plots

Proceedings of the Government of His Highness the Maharaja of Mysore

Read:—

Correspondence ending with letter No. Roc. 2949|Budget 37|37–38 dated 21st June 1938 from the Director of Agriculture, urging the need for the provision of a sum of Rs. 8,000 for demonstration plots in ryots' fields and of Rs. 2,000 for distribution of demonstration ploughs to 100 select villages during 1938–39 and requesting that as demonstration of agricultural improvements in ryots' lands is the most important item of Rural Reconstruction and of the work of the Agricultural Department, the sum of Rs. 10,000 may be set apart for the use of the Agricultural Department in the provision under '30, Grants for Public Improvements —5, Rural Reconstruction' in the Budget for 1938–39.

Order No. D. 631–33|A.E. 218–37–4, dated, Bangalore, the 22nd July 1938.

The proposals of the Director of Agriculture are sanctioned.

(*Sd.*) K. Srinivasan,
For Secretary to Government,
Development Department.

In continuation a sum of Rs. 10,000 has been included in the Budget of the Agricultural Department for 1939–40.

Demonstration plots are meant to grow in the raiyats' own fields on a small scale strains of crops which have practically passed the experimental stage, but with regard to which a demonstration is felt necessary so that the raiyats may take them up on a large scale after seeing them grow well in their neighbourhood. Just as new seeds are demonstrated so also are fertilizers and methods of culture.

'A' Farms

Proceedings of the Government of His Highness the Maharaja of Mysore.

Read:—

Correspondence ending with letter No. Roc. 302–H.C. 109–37–8, dated 16th March 1938, from the Director of Agriculture in Mysore, stating that in order to make available pure seed at comparatively low cost, 'A' farms have been organised in various centres of the State and pure seed purchased out of the grant under "W.A. Advances" supplied to 'A' farm growers and that it is necessary to allow credit to such growers as an incentive to undertake the cultivation of pure seed and sell the harvest to the Department, if required, and requesting sanction to the following proposals:—

(*a*) Supply of seed to 'A' farm growers on credit up to the limit detailed below subject to return of good seed in kind with 10 per cent. addition:

Paddy.—Rs. 25 (corresponding to 3 pallas of seed for sowing 10 acres).

Ragi.—Rs. 10 (corresponding to 2 pallas of seed for sowing 20 acres).

Groundnut.—Rs. 50 (corresponding to 10 pallas of unshelled nuts for sowing 10 acres).

(*b*) Purchase of select seeds from 'A' farms at 10 per cent. higher than the local rates by the Department for sale to the public, the loss if any, on sales being debited to the allotment under "purchase and transport" of the Departmental budget.

Order No. D. 703–04–A. & E. 134–37–8, dated, Bangalore, the 25th July 1938.

Government are pleased to sanction the proposals of the Director of Agriculture. The limit of credit is fixed at Rs. 25 in any individual case. Proper agreement should be taken to prevent loss to Government.

(*Sd.*) M. VENKATANARANAPPA,
Secretary to Government,
Development Department.

Note.—Sugarcane setts also are included in the list of seeds to be given for 'A' farms, *vide*, G.O. No. A.F. 3832–3|Agri. 162–39–2, dated 1–2–1940.

SELECTIONS

Some Methods of Composting Suitable for Small Holdings

Small holders often crop their holdings, season after season, without the incorporation of any kind of manure. This is a distinctly harmful practice, particularly in areas cultivated with annual crops like cotton, cereals, tobacco, and vegetables, where it is necessary to replenish the soil every season with some kind of organic manure such as farmyard manure or compost. Artificial fertilizers are usually beyond the reach of the average small holder; but he can easily provide himself with a supply of organic manure which will assist him to cultivate crops successfully and secure economic returns. Most cultivators have not as yet fully realized the benefits of organic manure. It is not an uncommon sight in the dry zone villages to find farmyard manure and other farm waste scattered about in the holdings, while vegetable plots in the neighbourhood are struggling for existence for want of plant food.

Small holders who possess cattle should never let them roam to find a precarious existence. Cattle should always be housed in a stall at night and fed. The most important requirement for this practice is a plot of Napier or Guinea grass, which grows admirably in most districts. If the practice of housing and stall-feeding is generally adopted in village holdings, not only will crops be safeguarded from destruction by stray cattle, but there will also always be a plentiful supply of farmyard manure, which with the other farm waste, could be converted into a valuable compost.

Farm waste should be collected as a regular routine operation. Even material such as kapok husks, cotton stems, maize cobs, etc., may be utilized provided they are broken up before use. Cattle dung should never be allowed to lie about on the land but should be stored under cover until required. Wood-ashes should be collected in receptacles. Where cattle are housed in stalls the urine-earth (which is the finer scrapings) should be gathered from the stall floor and utilized for composting with the farm waste. The coarse earth may be applied direct to the field for renovating the soil.

The Rain-fed Process

Preparation of compost by the rainfed process is not a difficult operation. The method may be briefly described as follows:—Collect

all farm waste such as weeds, loppings, sweepings, and straw, and spread it in the stall in the evening to serve as bedding for the cattle that will be housed at night. Next morning this material which has absorbed the liquid excreta, is gathered with the dung and heaped on a level and well grained site. A pit is not required, nor is roofing necessary to cover the heap as it is intended to be rainfed. The dimensions of the heap will vary according to the material at hand, but it is advisable to maintain the height of the heap at two feet. In farms where plenty of dung and waste are available, the following dimensions as recommended by the Institute of Plant Industry, Indore, may be adopted, *viz.*, 16 feet broad, 2 feet high and any convenient length. After the first few showers, the partially wetted mass of material should be raked up from a 4-feet strip on either side and heaped on the middle of the heap, thus reducing the breadth and increasing the height by about two feet. It is found that the greater depth so formed tends to check rapid evaporation of moisture during intervals when rain does not fall. It also tends to promote decomposition. Three weeks after the first turning, when the heap has sunk, the mass of rotting material should be entirely turned over to one side or end and heaped to the original height. A month after this operation, the last turning is done and the material heaped on the original spot. It is always advisable to turn the heap on a rainy day. If the rains are delayed, the turning should also be postponed until rains arrive. An extra turning may be necessary in the event of the heap not rotting sufficiently. The compost should be ready for use about four months after the commencement of the operation. One load of compost can be made from three loads of material.

In districts where the rainfall is uncertain, the process is accelerated if a crop of sunnhemp (*Crotalaria juncea*) is grown on the heap soon after the first turning. The growing sunnhemp is incorporated in the heap at the second turning. This operation promotes early decomposition. The manurial value of compost is enhanced by the addition of 6 to 12 parts by weight of steamed bone meal for every 100 parts of compost.

If the practice on a farm is to tether cattle in the open, the compost can be made at places conveniently near to where cattle are usually tethered. The farm waste can be utilized in the same manner as described above, and the material collected and heaped after mixing well with urine-earth and dung gathered from places where the cattle are tethered.

Compost Without Cattle Manure

In the absence of cattle and consequently of dung and urine-earth, compost can be made by using soft material such as weeds, straw, and loppings mixed with ordinary earth and wood-ashes.

In composting vegetable matter, it is advisable to add a little lime in order to reduce the acidity of the heap and so encourage bacterial activity. A small quantity of inoculant may be added to a new heap to hasten decomposition, but this is not essential as a well-made compost heap will in time cultivate its own micro-organisms. When an inoculant is used it is merely a supply of well-rotted material taken from a heap in which the decomposition is advanced.

In composting it is necessary to maintain aerobic conditions within the heap or some of the nitrogen will be lost. Insufficiently aerated compost has a sour smell. The turning over of the heap, after a shower of rain, restores aerobic conditions and conditions are essential for the normal activity of the fungi and bacteria concerned in compost making.

Covered Compost Heaps

In farms or holdings where there is a plentiful supply of leaves such as Dadap (*Erythrina lithosperma*) and *Gliricida sepium*, and where the application of such bulky material direct to the field is impracticable owing to the heavy cost of transport, a good compost can be prepared in the following manner:—Collect loppings of green material of the above-mentioned type. Remove the leaves from the branches and spread them out in the open, preferably in the evening, so as to remove excess moisture. Spread out the material next morning on a level and well-drained site in an area 12 feet long and 6 feet wide. This area should be surrounded by supports made of cadjans in preference to any other material as they permit of ventilation. A low cadjan roofing is necessary to cover the heap. A mixture should be prepared of cattle dung, one basket containing about 8 lb. of dung, 4 measures of fine urine-earth, 2 measures of wood-ashes, and 6 gallons of water. Sprinkle this mixture on the layer of leaves, which are spread out 3 inches deep, until it is well covered. Apply another layer of leaves (3 inches deep) and add a similar quantity of mixture. Repeat until the heap is 2 feet high. Leave the material for 16 days, by which time the heap will have sunk and packed. Mix up the material and heap it 2 feet high. The second turning should be done 16 days later and the heap should be built up to 2 feet again. The third and the last turning is done a month after the second and the original height again maintained. If at the third turning the material is found to be dry, add a mixture of cattle urine and water until the heap is just moist.

The compost will be ready for use about three months after the commencement of the operation.

The following is an analysis of a sample of compost made of *Pongamia pinnata—magul karanda* (S.), *punku* (T.), by this method;

Analysis

Moisture	.. ..	51·4 per cent.
Organic matter	.. ..	18·6 „
Ash ..	.. ..	30·0 „
Nitrogen	.. ..	·603 „

The sample is a good one and apparently made from green leaf material. Its nitrogen content is quite high.

—*Leaflet No.* 137, *Department of Agriculture, Ceylon.*

Fertility and Humus

Certain problems in agriculture are common to all branches of that industry, others are peculiar to the particular crop. Among the former is that of the maintenance of fertility. It is an old problem which was solved on practical lines in most countries when shifting cultivation gave place to settled cultivation. The basis of that change was the return of organic matter to the soil in the form of humus. In recent years the desire to get an ever-increasing return from his land has resulted in a forcing process through the addition of plant food in the form of artificials. The benefits which have followed seemed to justify this use, and in some cases the process has gone so far that reliance is placed solely on artificials for the maintenance of fertility. There is, however, a growing feeling that it is possible to have too much of a good thing; that, in spite of the immediate response, there is a progressive deleterious effect which will, in time, bulk larger than the beneficial results.

That reaction, in certain of its aspects, was voiced in a recent article in this *Journal*.[1] Since that article appeared further evidence has been forthcoming which, as the question of fertility is common to all agricultural enterprise, will be of interest, though most of it does not concern the sugar industry directly. In a recent report of a company which is concerned mainly with the production of tea and in which the present writer holds fewer shares than he would like (an indication that the company is prosperous and well managed), the following remarks occur:

"Particular attention is being paid to the soil fertility and the prevention of soil erosion and great progress has been made in these respects. The maximum use is being made of all waste materials which, with the inclusion of cattle manure, are broken down and returned to the soil in the form of compost. We do not attach great importance to chemical analysis in this connection, but those which have been made show a high nitrogen content. Fields treated with

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[1] *I.S.J.*, 1938, p. 216.

compost are looking as healthy as those treated with artificial manures at double the cost and are giving all the yield we require under restriction and, in the circumstances, the stout opposition to the process in some quarters is not unnatural. In the course of the last year we returned to the soil in the form of compost 25,872 tons of organic matter rich in humus, and this year we estimate to apply about 35,576 tons."

That is one example of the way in which the reaction is taking practical form, but only one. It is stated on good authority that to-day, only five years after the introduction of the process, a million tons of compost are being made annually on the tea estates of India and Ceylon. Nor is the movement confined to the tea industry of India and Ceylon; it is being actively pursued with rubber, coffee, sisal and other crops in many continents and receiving a growing number of adherents in temperate agriculture.

There is accumulating evidence to show that the problem of fertility is not the simple one it had been thought capable of mathematical solution; the addition of so much plant food yielding so much increase of crop. Nature does not work so simply; there are subtle biological influences at work, more prominent in tea and certain other perennial crops, perhaps, owing to the presence in these of a mycorrhiza, a symbiotic association of specific fungi with the root of the crop plant, but important in all circumstances in view of the role played by micro-organisms in the soil.

The mechanism by which the mycorrhiza acts as intermediary between the humus and the crop plant is undetermined; the recognition of its importance is too recent. Much valuable information as to the reality of some mechanism is supplied in a paper by A. Howard.[2] The association of bacteria with the roots of leguminous plants, leading to the formation of nodules, has been known for a very long time. It is the capacity of these bacteria to fix free nitrogen for the enrichment of the plant that renders leguminous plants so valuable as manure. But the story does not end there; nodule formation is not adequate to carry the leguminous plant to maturity without the addition of humus to the soil. Plants such as *Crotolaria anagyroides*, grown to supply green manure, commonly fail to set seed under the monsoon conditions of India unless supplied with humus, and it is of interest that an examination of the roots of *C. anagyroides* which had been manured with compost showed both nodules and mycorrhiza but never together on the same rootlets. Further, leguminous vegetables like French beans, when grown on poor soil only or under the stimulus of artificials, are tasteless and of poor quality, and the question is

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[2] *Empire Cotton Growing Review*, 1938, **15**, p. 215.

asked whether quality and disease-resistance both depend on the same factor, the perfect synthesis of proteids and carbohydrates. It would seem so and that this perfect synthesis results from the presence of a vigorous mycorrhizal development, for the response to compost on worn-out tea lands has been immediate, far greater than can be explained by any improvement in the physical condition of the soil and accompanied by very definite increased resistance to red spider (*Tortix*) and mosquito blight (*Helopeltis*), those two pests of tea. An account, too, is given of an estate in Lincolnshire, where a balanced system of agriculture based on compost has been adopted. Thirty-five acres of this 325-acre estate are under intensive garden cultivation, and for the last two years no chemicals have been used at all either as fertilizers or as sprays for disease and pest control. On the farm land the amount of artificial fertilizer has already been reduced from 106 tons to 40½ tons with a saving of nearly £400 per annum, and it is expected that the farm too will shortly become completely independent of artificials.

The nature of the mechanism is, as has been said, undetermined. There may be in the compost growth-promoting substances for which the mycorrhiza forms a protected passage to the plant thus protecting them from absorption by the soil population, or the fungi may be capable of providing essential materials for the manufacture of such substances in the plant itself. Further work alone will determine the question. Meanwhile some indication as to the nature of these substances is given in a paper by H. Nicols.[3] There is a group of substances of which indole acetic acid is an example, closely associated with the excretory products of animals, which are known to promote growth, or as here expressed, regulate growth. Already their use has been commercialised in the product Hormotone used for stimulating the rooting of cuttings. Their association with the excreta of animals, used in the preparation of humus, is suggestive.

The gradual progress of scientific discovery in its bearing on practical problems appears to be subject to interruptions when a light appears which throws open a whole new field in man's command over nature. Of such a kind were those of Liebig, Pasteur and Mendel, to mention only three in the biological field. It is possible that, in the agricultural field, the recognition of the importance of the role of mycorrhiza may play as important a part. There is reason to believe that mycorrhiza will be found associated with the roots of many agricultural plants and it is understood that its presence in association with the roots of the sugarcane has been observed. Nature appears to have provided this special mechanism for the utilization of humus

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[3] *The Manufacturing Chemist*, 1937, **8**, p. 175.

and mycorrhiza has been observed in a sufficiently diverse series of plants to suggest that the phenomenon of its presence is more general than has hitherto been supposed. Should that prove to be the case, the bearing of the fact on future manurial policy and on disease resistance becomes obvious. Meanwhile, it is not necessary to await the detailed determination of the mechanism; sufficient is already known to permit advance on the practical application.

If the tea industry of the East has led the way in this return to a more natural practice in the use of compost, it is not the only example. The list of countries and industries where that use is growing would be a long one. The sugar industry, for reasons which it is not easy to account for, unless it be that the depression which has reigned now for so many years has forced the cane grower to concentrate on the immediate future, appears to be still wedded to the use of artificials and, in some countries, notably the West Indies, the old-established use of natural organic manure in the form of pen manure has largely been replaced by artificials. But the cane sugar industry is turning its thoughts in the same direction as indicated by a recent paper read before the South African Sugar Technologists' Association.[4]

The author, G. C. Dymond, commenced with the statement that the continuous stimulation of vegetable crops by artificial fertilizers is symbolic of our synthetic civilization, the age of quick returns, and leaving any consequences for the next generation to worry about, and referred to the accumulating uneasy feelings of decreasing fertility and the increasing susceptibility of plants and animals to diseases, through a reduction in those nebulous conditions, which may be termed stamina and quality.

The available waste products of the cane sugar industry were dealt with in a recent article[5] and the bulkiest of these is trash, which is variously estimated as between 14 and 22 per cent. of the cane crop. The various methods of dealing with this waste and the unsatisfactory use at present made of trash are described and the author points out that the problem is one of cost. That it has a potential value as a basis for compost and would be more profitably used in this manner is undoubted. As he expresses it:

"The economics of composting resolves itself into the following basic factors: trash is on one field; the dung (if any) is at the stables; the filter cake or dunder is at the sugar factory or distillery; the green material somewhere else and the water anywhere or nowhere; while the result may be required somewhere else."

After giving analysis of compost from trash with various materials, he made reference particularly to dunder, a product of the distillery,

[4] *Humus in Sugarcane Agriculture*, 1938.

ne disposal of which is frequently a serious problem. A circular heap f trash 9 yds. in circumference and 2·5 ft. high is stated to contain 60 lbs. trash and to be capable of absorbing 600 gallons of dunder o two months, even when, as in the case quoted, 20·8 in. rain fell. On this basis it is calculated that the out-turn of dunder from a distillery producing 4,000 gallons of alcohol per diem would handle trash rom 1,440 acres of cane yielding an average of 25 tons per acre. From nalyses of the product it is calculated that this would represent over 80 tons nitrogen, 30 tons phosphoric acid and 36 tons potash. It is ecommended that the trash should be a few months old before being composted, as also that, after the heap is turned, a green crop be planted on the heap and turned in.

Filter cake is stated to be a better medium for composting trash han cattle dung and the product has greater manurial value. It is uggested that this might be loaded direct from the presses in the orm of a thick slurry into tank cars and discharged on to the heaps f these are placed along the tram route. This raises the question f the best locality for making compost. The alternatives are collecting he trash as left in the field on stripping the cane, for which some nechanical means like the Hosier rake will probably be cheaper than hand labour, or cane may be loaded into the wagons unstripped and stripped at the Factory.

The position is summed up in the following terms:—

"Artificials are easy of application, easily purchased in good times or not bought at all when times are bad; they form a never-ending topic of conversation with one's neighbours, a source of argument with the vendors; they are a duty and a sop to one's conscience; whereas humus means more labour, more attention, transport and rouble. Nevertheless humus is the basis of permanent agriculture, artificials the policy of here to-day and gone to-morrow."

—*The International Sugar Journal*, Aug. 1938.

Are Cultivations Overdone?

BY

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In most countries, and especially in Great Britain, farmers have a traditional belief in the necessity and the virtues of thorough soil cultivation. The *necessity* of some minimum amount of cultivation is elf evident but, in our climatic conditions of well-distributed annual rainfall, it is commonly believed that cultivations additional to this minimum are essential, especially on medium and heavy soils, to secure

[8] *I.S.J.*, 1938, p. 6.

a satisfactory tilth. The *virtues* of thorough cultivations cannot be so precisely defined, but it appears that most farmers believe the quality and yields of crops are improved by additional and deeper stirrings of the soil.

Whatever the reasons, the fact remains: even in the present difficult times, the great majority of farmers strive to keep up a high standard of cultivations, which still rank as probably the heaviest single item in the arable farmer's budget, and are certainly more expensive than his annual payment for fertilizers. Nevertheless, large numbers of manurial experiments have been and are being made, and the cumulative results are constantly being used to improve farming practice. But nothing of the kind was ever done for cultivations, probably because it was felt that the results would merely confirm the obvious.

In this connection it is important to realize that our present accepted standards of cultivation grew up when there was an ample supply of low-wage labour and tractors were unknown. Putting men and horse teams on to a cultivation cost very little more than letting them stand idle, because wages had to be paid and horses fed in either event. In tricky seasons it was often impossible to finish the work before rain or drought came, with the common result that extra cultivations were afterwards necessary to bring the soil to the accepted standards of good tilth. From such considerations as these the traditional attitude to soil cultivation arose naturally and inevitably. The vital question is whether the tradition embodies a fundamental truth to be neglected at our peril, or whether, in the changed economic conditions our standard of cultivations can be lowered without detriment. It may be said that the present wage level in relation to prices received for farm produce is forcing the farmer to lower his level of cultivations; it may further be argued that the tractor, by its superior speed and power, has reduced the number of cultivations required in tricky seasons; and attention may be directed to the fact that the tractor differs from the horse in needing fuel only when it is working, and thus (if properly cared for) costs nothing when it is idle. These arguments, although admittedly important, especially in their application to mechanized grain farms, deal primarily with problems of the best form of motive power for cultivations and questions of labour organization. They are not directed towards the fundamental questions; what is the real purpose of cultivation; and are our standards wastefully high?

The real purpose of cultivation can be easily defined: it is to secure a suitable seedbed for the particular crop and maintain the soil in the best condition for plant growth throughout the life of the crop. Most text-books of practical agriculture give extended explana-

tions of how the various cultivation operations achieve this end. Some are designed to allow the weather to act to the best advantage; autumn ploughing is an obvious example. Others are said to control the moisture conditions: thus, harrowing is believed to break the capillary films of moisture in the pore-spaces of the soil, so preventing further rise of water to the surface and thus reducing evaporation losses; rolling is believed to draw up moisture to the young plant from below, because the superior capillary pull of the smaller pore-spaces in the compressed top layer of the soil. These explanations, however, can no longer be accepted. They are based on the capillary theory of soil water movement which, although simple and plausible, is now disproved. Water does not, in fact, move from one place to another in the soil in the manner predicted by the capillary theory. It is relatively static and is either absorbed by plant roots that go in search of it or else it evaporates *in situ,* passing as water vapour into the larger pore-spaces and thence into the air. If the state of affairs pictured by the capillary theory were correct, the amount of water present would have to be such that rolling would have a disastrous effect on the tilth.

The text-book discussions of the effect of weather on tilth production are on sounder lines. The effect was well brought out by some results obtained at Rothamstead on autumn-ploughed land at the time of spring cultivations. In one instance the winter of 1927–28 had been mild and wet; in the other instance the winter of 1925–26 had included dry spells and periods of frost. The condition of the soil immediately before the spring cultivations was measured by taking a block of it with minimum disturbance and placing it on a nest of wire sieves with square apertures ranging from 1½ in. side in the top sieve to 1/10 in. side in the bottom one. The nest was gently shaken until disintegration of the block had ceased. The proportion of lumps of different sizes into which the block had disintegrated was ascertained by weighing the contents remaining on each sieve. As would be expected, the soil after the hard winter broke up very easily into small and medium-sized pieces and only a few lumps were left on the top sieve. The furrows were well weathered, and ready to fall down to an excellent seedbed, and called for no cultivation treatment beyond a single harrowing to level the surface. The behaviour of the soil after the mild and open winter was in striking contrast. Nearly two-thirds of the block remained on the top sieve in the form of large unkindly lumps.

Similar sieving measurements were made in each case immediately after the spring cultivations, and by comparing these results with those just discussed a measure of the disintegration produced by the implements was obtained. The implements employed were a ridging or

bouting plough and a rotary cultivator (the Rototiller). On the weathered soil these implements produced little effect: there was a slight increase of the smaller-sized crumbs at the expense of the medium-sized ones, and the small number of large lumps was further decreased. But on the unweathered soil it was necessary to employ the drastic combination of rotary cultivator *plus* ridging plough before the soil could be disintegrated even to the extent displayed by the weathered soil *before* its spring cultivation. Nor was this all; for, although the sieving results showed the mechanical disintegration was about the same in these two comparisons, their state of tilth differed greatly. The unweathered soil showed what the farmer aptly calls a "forced" tilth, in marked contrast with the friable porous crumbs of the weathered soil.

As it appears that a primary purpose of cultivation is to allow the weather to act on the soil to the best advantage, and as the assertions, based on the capillary theory, that moisture movements can be delicately controlled by appropriate cultivations no longer apply, it is natural to enquire whether crop yields are, in fact, affected by the number and type of cultivations given to the soil. As already stated, no serious investigation of this important matter was ever made in this country. About twenty years ago many experiments were made in the United States with special reference to the Great Plains region of limited rainfall. The results showed that deep cultivation was no better than shallow; that mulching did not conserve moisture; that the main object of cultivation, apart from loosening the soil for a seedbed, was to cope with the competition of weeds for the available food and water; and that the direct effect of cultivations on crop yields was negligible. This work received little attention in Great Britain owing, probably, to the feeling that results in dry-farming conditions could not apply in this country. Some twelve years ago experiments were begun at Rothamsted to measure the effect of cultivation on crop yields, with the full expectation that the more thorough the cultivations the better would be the yields. During this period the experiments have consistently contradicted our initial belief and we have been driven to conclusions that tally closely with those reached in the United States. Recently, experiments have been made at Cambridge that give results similar to ours.

The full details of the Rothamsted experiments will be found in *the Annual Rothamstead Reports*. A full discussion appears in the *Journal of Agricultural Science* for 1938 and a summarized account is given in Vol. 98 of the *Journal of the Royal Agricultural Society of England*. Hence in the present article all details are omitted.

Sub-soiling.—On the Rothamsted soil a compressed layer or plough-sole tends to form and it is generally believed that subsoiling or

deep ploughing is desirable in such conditions, especially for crops like sugar-beet. In 1928 the land was subsoiled to 14 in. behind the plough for a crop of sugar-beet. The mean yield of beet in this experiment was 9·15 tons p.a., and the increase due to subsoiling was less than 1 cwt., so the cost of the operation was wasted. In 1931 a more drastic trial was made and the subsoil was thoroughly broken up by hand forking, but the labour of double-trenching, far from producing an increase, gave a decrease of nearly 5 cwt. p.a. on a mean yield of 12·66 tons p.a.

Extra Ploughings.—In 1934 two experiments were made, one on potatoes and the other on sugar-beet, to see the effect of withholding either the autumn or the spring ploughing, both of which constitute the normal preparation for root crops. In the potato experiment one set of plots received spring ploughing only and in the sugar-beet experiment autumn ploughing only was given to some plots. The yields were compared with the remaining plots that received both ploughings. In each case double ploughing produced an increase: 5 cwt. of potatoes on a mean yield of 11·43 tons and 7 cwt. of beet on a mean yield of 15·36 tons, but in neither case did the cash value of the increase pay for the cost of the extra ploughing.

Seedbed Consolidation.—Occasionally it is noted that crops show better growth over the tracks of tractor wheels than in between. In cereals the effect is sometimes strikingly shown by parallel bands of taller growth running across the field. The possible relation between compression of seedbed and plant growth requires much further study, and there is no obvious reason why it should be confined to cereals. For example, it was noted at Rothamsted that sugar-beet germinated better and grew more rapidly on an area that had been heavily consolidated in the previous winter by the passage of laden farm carts, and in 1934 and again in 1935, experiments were made to see the effect of heavy rolling of the seedbed for sugar-beet. An adequate measure of the percentage of germination was given by counting the number of plants per acre before harvesting. In 1934 there were about 3,000 additional plants per acre on the heavily rolled plots; nevertheless, the yield was 9 cwt. less than the mean of 14·03 tons p.a. In 1935, heavy rolling produced small reductions both in germination and in yield. Hence in neither year did the extra operation give any benefit.

Intensive Inter-row Cultivation of Root Crops.—The root break is the cleaning crop in the rotation, and there is a common belief that beneficial effects on the yield are produced by inter-row cultivation in addition to the direct effect of weed eradication. In 1932, 1934 and 1935, five experiments were made to see whether extra inter-row cultivations improved yield. At Rothamsted three of the

experiments were on sugar-beet and one on kale, while the remaining experiment, on sugar-beet, was done on the light, sandy soil at Wouburn. The "normal" cultivations consisted of hand, horse, or motor hoeing, sufficient to keep down weeds; the number ranged from two to five depending on the season. The remaining plots were given an additional three to six hoeings after singling, again according to the season. The results were as follows:—

	Sugar-beet				Kale
	(1)	(2)	(3)	(4)	(5)
Mean yield, tons per acre ..	13·5	15·4	11·9	11·6	25·5
Increase (+) or decrease (−) with extra hoeing .	−1·03	−1·79	−0·23	+0·25	−1·84

The figures are striking. In two of the experiments, Nos. 3 and 4, extra hoeings produced no appreciable effect on yield; in the remaining three a significant reduction of yield was the reward for the additional cost and labour of the extra hoeings.

Rolling and Harrowing of Cereals.—These experiments were done on wheat in 1931 and 1933. Four comparisons were studied: harrowing alone, rolling alone, harrowing *plus* rolling, and no harrowing or rolling. In both years harrowing *plus* rolling gave the best results in grain yield: in 1931 a significant increase of 2·1 cwt. over the mean yield of 15·8 cwt. p.a. and in 1933, when the mean yield was 23·3 cwt. p.a. an increase of 1·4 cwt., which was, however, below the level of significance. In both years the yield of straw was slightly but insignificantly depressed by the combined operations. Harrowing without rolling produced the same effects on grain and straw yields as the combined operation, but to a smaller extent. Rolling without harrowing gave a small increase in grain yield, but an appreciable increase in straw yield. Hence, as far as these experiments go they give support to the practice of rolling and harrowing cereals.

Depth of Tillage: Rotary Cultivation.—These two questions can conveniently be considered together as the results to be discussed were obtained from an extensive three-course rotation experiment (mangolds, barley, wheat) comparing the plough, the cultivator or grubber, and the Rototiller, each implement being used for shallow work (4 in.) on some plots and for deep work (8 in.) on others.

The main objects of this experiment, now in its sixth year, are to study the effect of depth of tillage on yield and to see how far rotary cultivation can replace traditional methods. The cultivator of grubber was included as one of the main treatments, as its stirring

action on the soil is intermediate between the inversion produced by the plough and the mixing action of the rotary cultivator. In addition, it was anticipated that the weed population of the plots would vary with the type of cultivation and thus provide information on both the efficiency of weed control under different cultivation methods and on the effect of weeds on crop yield.

The main results to date are as follows:—

Although crops have germinated quickest on the loose seedbed prepared by rotary cultivation, this has conferred no advantage as far as the subsequent growth and yield are concerned. In fact there has been a slight tendency for ripening to occur earliest on the ploughed plots.

The yields of wheat, barley and mangolds have been about the same with all three methods of cultivation, provided the grubber or rotary cultivator are used for one year only. When employed for several years in succession the yield has sometimes deteriorated. The effect however, is probably attributable to the increase of weeds, rather than to any direct defect in the type of cultivation. The practical conclusion is that in any year when time presses, quicker and cheaper cultivations can replace ploughings without any appreciable drop in crop yield.

Increased depth of cultivation has been without effect on crop yield, except for mangolds on the area devoted to continuously rotary tillage. Here the 8-in. depth of cultivation has kept the yields approximately to the level obtained on the ploughed plots, while on the 4-in. depth of rotary cultivation there has been a decline.

As would be expected, the grubbed and rotary cultivated areas have become more weedy than the ploughed area, but the effect on crop yield has not been appreciable except when these implements have been used for a number of years on the same area.

Conclusions.—Under the soil and climatic conditions at Rothamsted little or no advantage is gained from cultivations above the minimum needed to obtain a reasonable seedbed and to check weeds during the early stages of crop growth. Deep cultivations such as subsoiling produce no increase of yield; intensive inter-row cultivations of root crops significantly depress the yield. Ploughing can be replaced by the quicker and cheaper operation of cultivating or grubbing whenever time presses without appreciable detriment to the yield.

These results agree closely with work done elsewhere in different soil and climatic conditions and support the conclusion that cultivation has little influence on crop yields.

It is quite certain that at the present time most farmers will deny this conclusion, but the facts remain. The experiments have extended

over a 12-year period; the cultivations were all normal operations, done by skilled farm workers and controlled by a skilled farmer; they cannot be dismissed as unpractical experiments bearing no relation to farm conditions.

The very important question arises as to how far these results are representative for other soils. There is a probability, but no certainty, that they are typical for medium and heavy lands where the annual rainfall in less than about 35 in. It is therefore highly desirable that cultivation experiments should be made on as many different soil types as possible.

—*The Journal of the Ministry of Agriculture,* Vol. XLV, No. 7.

The Cultivation of *Cajanus cajan* and the Methods of Preparing Marketable Dhal

Cajanus cajan (*C. indicus*) is considered to be one of the most promising legumes at the present time. It is one of the favourite crops of the average village cultivator for a variety of reasons. The Indian farmer has recognized its value in the light of his accumulated experience extending over several centuries. The scientific study of agricultural problems during recent years has confirmed its recognition by the cultivator. It occupies a predominating position among the pulse crops of India and is used as a restorative, rotational or mixed crop.

From the point of view of keeping the soil in fertile condition in dry and arid tracts, there is hardly a leguminous crop that can stand comparison with it. Being a drought-resistant crop, it grows successfully in tracts receiving annual rainfall of 25 to 30 inches or even less. It has been known to have grown successfully in some dry seasons when other crops have failed. It has a deeply penetrating root system which enables it to open up any hard set soil to a great depth thus aerating the soil and bringing it to a much finer state of physical condition for subsequent crops. Throughout its growing period and particularly during the later stage it sheds a large amount of leafy material which definitely enriches the soil in valuable organic matter. Like other leguminous crops, it also fixes atmospheric nitrogen in the soil. From the economic point of view, the crop possesses some commendable features. The plant yields seed which affords a nutritious article of food. The leaves, the husk of pods and the seed-coats, which are all by-products of the crop, are utilized as excellent feeding stuffs for the milch and draft cattle of the farmer. The stalks supply him his domestic requirements of fuel. The cultivator usually sells the surplus grain for which he finds a ready market. The crop has, therefore, many desirable features in its favour, *viz.,* it furnishes

food for the farmer's family and cattle, provides fuel, and helps to maintain the fertility of the soil while it is also a money crop.

The pulse is used in a variety of ways but its chief use is in its split form as *dhal*. Dhal contains as high as 18 to 20 per cent. proteids and is, therefore, of definite value to a vegetarian population. The tender pods of this crop are extensively used as a vegetable in the same manner as garden peas. An Indian cultivator living near a market sells the first part of his crop in the form of green vegetable pods and allows the pods which form later to mature for the production of seed.

The plant has further uses. During recent years it is being developed, particularly in the United States of America, as a leguminous fodder crop and in this respect is likely to rival lucerne in importance. It does not require such careful management as lucerne. Being a drought-resistant and hardy crop it grows well in any soil under adverse conditions with little attention. It matures for fodder comparatively rapidly and is capable of being utilised as a perennial fodder crop. Live-stock and poultry relish the crop. It has also been recommended as a green manure crop. According to leaflet No. 14 of the Ceylon Department of Agriculture, it may be grown as a green manure crop interplanted with young rubber and coconuts in tracts receiving less than 100 inches rainfall. However, as a green manure crop for annual crops it does not compare favourably with other well-known green manure crops on account of the comparatively slow habit of growth and the large proportion of woody material in the plant. It is also grown as a shade crop, cover crop, and occasionally a wind-break hedge plant. In Assam, for example, it is grown as a border crop round sugarcane fields more for the protection of the cane crop than for the yield of its seeds. In such cases the dry stalks serve the purposes of a much needed fuel in boiling the cane juice.

Varieties

The plant is known to have a large number of varieties with slightly different characters, growing under varying conditions in many parts of India. The recent survey of the varieties of this plant by the Imperial Economic Botanist at Pusa (*Scientific Reports of the Agricultural Research Institute*, Pusa, 1928–29, page 21) shows the number of distinct types obtained was 107 indicating great variations in height, habit of growth, the time of maturity, colour of flower, colour and shape of pods and the size, colour and shape of seeds. The varieties, however, can be subdivided into main groups. The first comprises the perennial type which assumes a tree-like appearance and is allowed to grow more than a year. From the point of view of yield of seed, this variety yields a fairly good first crop but the

yield in subsequent years falls considerably. This type is used more as a shade, fodder, cover, or hedgeplant than for seed. The small or annual type is mostly grown as a field crop for its seed. The size, shape and colour of seed vary in different varieties. The white seeded variety which is grown in Gujarat, Western India, yields a very fine quality of *dhal* fetching the best market price. The red or the brown seeded variety does not grow well in the heavy black cotton soils of Gujarat and is mostly confined to the lighter type of soils south of Bombay.

Soil and Climatic Requirements

Cajanus cajan is grown mostly in mixture with a large variety of crops under a wide range of soil and climatic conditions. This fact indicates that the plant is quite capable of adapting itself to widely variable conditions. Under dry conditions it comes to maturity fairly quickly. Under humid conditions as would be expected the crop tends to produce luxuriant vegetative growth. Cloudy weather and rain at the flowering time causes defective fertilization and the pod-caterpillar appears on the crop damaging the growing pods. Stagnant water in fields is definitely harmful to the crop.

The wet zone of Ceylon is rather unsuited to the successful cultivation of this crop for seed production. The climate is likely to prove too humid and the flowering is liable to be affected. In the dry zones subject to one monsoon only and where the rain has almost ceased by the time the plants come into flower, the crop would naturally grow well. Moreover there is every possibility of finding a strain suitable for any given local conditions from among the large number of varieties growing under a wide range of climatic conditions in India. If the aim is not the production of seed, the plant may be grown in the wet zone and will produce luxuriant vegetative growth for purposes of fodder, shade, cover, hedges or windbreaks.

Methods of Cultivation

In India the *Cajanus cajan* crop is usually grown as a mixed crop. It is sown in widely spaced lines as a subordinate mixture with other crop or crops of a shorter growing period, such as sorghum, maize, bulrush millet, other millets, gingelly, groundnuts, etc. These intervening crops, being of a shorter duration than *Cajanus cajan,* are ready for harvesting first. The *Cajanus cajan,* achieves its full growth after the maturity or removal of this intervening crop and is then able to utilize all the additional space made available between the rows.

Because of the fact that it is raised as a mixed crop, the soils available for this crop naturally vary with the requirements of its accompanying main crop. For example, with sorghum it will occupy

a heavier clay loam type of soil; with millets, groundnut and gingelly, it will occupy a lighter type of loam to sandy loam soils. Usually it does not require manures but if grown on a newly opened or well-manured land, growth is luxuriant. As with any other leguminous crop, the soil for this crop should not be deficient in lime. The character of preparatory tillage will be determined by the requirements of its associated crop. In India it is usually sown at the commencement of the south-west monsoon in June or early in July and is for harvesting by February or March. The other crops grown in association are usually harvested by the first week of October. The period from October to March is more or less dry and rainless. The crop does not require any irrigation during this long dry period because it is able to draw its own moisture requirements from lower depths with the help of its deeply penetrating root system.

In a common and typical form of mixture *Cajanus cajan* occupies every fourth row of the mixed crop which is either drilled by a special attachment to the country plough called *Mogan* or is dibbled behind the country plough in a line just opened by it. The *Cajanus cajan* will thus be in rows 4 to 6 feet apart depending upon the type of its associated crop and the spacing given to it. The seed rate with this type of mixture varies from 1½ to 3 lb. per acre. In the case of an unmixed *Cajanus* crop, the seed rate would amount to about 8 lb. per acre. In South India where it is sometimes grown mixed with groundnuts, the distance allowed between the two rows of *Cajanus cajan* is 10 to 25 feet. The object of keeping it so wide apart is to keep the groundnuts as far as possible free from shade. The seed rate in this case is naturally very low and depends upon the actual spacing.

After germination is completed the plants have to be thinned in the rows to a space of about a foot apart in light soils. In good and deep soils spacing may be done at two feet apart.

During the first 4 to 6 weeks, the crop shares the useful intercultivation given to the main crop. The crop is then usually allowed to take its own course. There is a belief in India that the more this crop is trampled when the main crop is harvested the greater will be the subsequnt development of branches, flowers and pods. When grown with groundnut in South India, the soil has to be dug over for removing the groundnut and this serves the purpose of a final cultivation without extra cost. If seed production is the object, the crop is allowed to remain standing in the field till the pods dry on the plants.

When it is used as a perennial crop, the branches are cut off for feeding cattle whenever required or at regular intervals. At the close of the season, the plants are pruned to about 2 feet above the ground. With the advent of the new season's rain, the pruned plants will start

growing again. Thus the crop can be made to yield a large amount of leafy material in humid tracts for 3 to 5 years. It is, however, equally easy to renew the sowings every year.

Harvesting and Threshing

The crop is harvested by cutting the whole plant close to the ground by means of a sharp sickle. The actual treatment of the plants after they are cut depends upon the prevailing local conditions. Where there is risk of damage by rains or by thieves, the plants are tied into small bundles soon after they are cut and carted to the threshing floor. Bundles are then allowed to remain there for a few days till the green leaves left on the plants completely dry off and the ripe pods open slightly. If the possibility of damage by rain or by thieves does not arise, the harvested plants are collected and left in the field for a day or two till they are fairly dry and then carted to the threshing floor early in the morning to avoid shedding of seeds from the dry pods.

The threshing is usually done by vigorously shaking the dry plants. A good many pods and seeds with leaves are thrown out. Those that do not drop by shaking are finally beaten with strong bamboos or wooden flails. When everything has dropped from stalks the material is further beaten by sticks or trampled under the feet of bullocks which completely separates the grain. The grains are further cleaned from the chaff by subsequent winnowing. The chaff so separated is a good feeding stuff for draft cattle. The stalk are mostly used as a fuel. Thin and straight stalks or branches are used for roofing or for making the sides of the bullock carts.

Yields

As a fourth row mixture, the yield of seed ranges from 300 to 600 lb. per acre depending on the type of mixture adopted and the soil and climatic conditions under which it is grown. A bushel of seed usually weighs 56 lb.

Method of Marketing in India

The seed produced by village cultivators is usually brought by them in cartloads to primary markets located in small towns near-by. Here the professional dhal-makers locally known as *golas* buy the produce with a view to making dhal out of it.

This professional class of *golas* is found in most of the small towns all over India. To them dhal-making is a fairly profitable small-scale industry extending over the greater part of the year. They are a class of people with limited means and work with the small hand-operated splitting mills run by hired labour. The methods of milling

slightly vary in different districts. A few enterprising *golas* keep several such mills and work with a larger labour force during periods of demand. Large-scale modern mills operated by mechanical power have not been erected to any appreciable extent chiefly because the people engaged in this industry are of limited means and also because most of the villagers are producers as well as consumers of dhal. A few power mills are to be seen in some large towns. Some of the cultivators who appreciate the value of home-made products make their dhal from their own farm produce. To them the necessity for selling the grain to *golas* and later buying the dhal from them does not exist. The dhal produced by the cultivators themselves is of good quality because of the great care exercised by them. Most of the dhal produced by the cultivator is for the use of his own family and only the small surplus disposed of. As will be seen later, the process of dhal-making is quite simple, and every cultivator can prepare his requirement with little effort unless he has a more important call upon his time.

Preparation of Dhal

The particular method of preparing dhal adopted has an important bearing upon the final quality of the commercial product. It may therefore be useful to discuss first the points which decide the quality of dhal. Dhal is chiefly used as a food in boiled form. A good quality of dhal should be easily and quickly reduced by boiling to a homogeneous semi-liquid mass. After boiling it should not continue to retain its original form or shape and should not show any unbroken hard pieces. If the dhal becomes soft in a reasonably short period of boiling, the flavour and taste of the cooked product is better than if boiled for a long time. This quality of softening after brief cooking should be retained during the storage period. This is the second important consideration of quality. Any sample of dhal, therefore, which cooks soft quickly and retains this quality during a fairly long period of storage is regarded as of good quality.

There are two well-defined methods of preparing dhal in India. Each is practised under certain local conditions and has its own advantages and disadvantages.

The first is the "dry method" which is chiefly used in Gujarat and parts of Northern India. The dhal obtained by this method softens rapidly on cooking and the resulting flavour is very good. The method of preparation is costly, and the proportion of broken dhal is comparatively more. The dhal obtained by this process is of the perfect shape of a half moon. It realizes a very good price in the market.

The second is the *wet method* in which water is freely made use of. Something like controlled malting takes place. The resulting

dhal is hard to cook after a short period of storage and is not then fully reduced to a homogeneous semi-liquid mass even after prolonged boiling. The flavour is not so good as in the dry method. The method has the advantage of cheapness. Another advantage in its favour is that the proportion of broken dhal is very small and therefore the percentage of dhal recovered by this process is much greater. The dhal obtained has a semi-round shape depressed in the centre. This process is extensively used in South India extending up to Bombay Deccan with slight local modifications.

Both processes require ample sunshine for thorough drying of the seed preparatory to dhal-making. Therefore the availability of bright sunny days is the first important essential for successful dhal-making. Such conditions obtain in the dry zones of Ceylon and thus make possible the creation of a small village industry providing occupation throughout most of the year.

The splitting mill used in both of the above methods is a mill with two circular stones one of which rotates round an axle fixed perpendicularly at the centre of the lower or bottom stone. The axle passes through the upper stone which is provided with a centre hole through which the grains are fed into the mill. There is another small hole near the circumference of this upper stone where a strong peg is fixed. By means of this peg the upper stone is made to rotate round the axle. The pulse seed is thereby split up into two halves or cotyledons and the seed-coat is separated. The pulse seeds are fed through the hole in the centre and the split dhal is collected below round the stone. The stone mill used in Gujarat generally weighs about 120 to 150 lb. and costs Rs. 15 to Rs. 25 depending on the quality of stone used.

Dry Method of Making Dhal

This process can be conveniently divided into the following seven stages:—

1. *Preliminary sun-drying.*—The seeds are exposed to hot sunshine for three to four days. If the temperature is below 90° F., drying may have to be prolonged for a longer period.

2. *Preliminary and partial splitting of grains.*—This is usually done at noon. The grains are taken from the drying place and they are fed to the splitting stone mill in a hot condition. The grains are fed rapidly in large quantities at a time. The object is to get the seed-coat pressed and effect some cracking of the seed-coat while the seeds are moving in a hot condition between the stones. Along with cracking of the seed-coat, about half the seeds split into cotyledons but their coats are not removed. The partially split seeds with cracked seed-coats at this stage of the process are known as *dol*. The above two

stages of the process can be carried out soon after bringing the produce from the fields if desired, or at any other suitable time.

3. *Treating the dol with vegetable oil and storing it.*—The *dol* so obtained is not usually made into the final dhal immediately. It is treated with a small quantity of vegetable oil at the rate of about 2 lb. per 100 lb. of *dol,* and stored for varying periods. If the storage period is to extend for more than a month castor oil is used; gingelly oil being used if the storage period is less than a month. Storing of *dol* treated with oil for at least a fortnight is considered necessary. The chief object of treating *dol* with oil and storing it for some time is to allow the slightly cracked seed-coat of the pulse to absorb the oil making the seed-coat soft and thus assisting considerably in the final splitting of the pulse into dhal and the removal of the seed-coat from the split dhal. The treated material should remain oily during the entire period of storage. The variation in the storage period offers an opportunity to distribute the dhal-making business over a longer period of the year so that it can be done at convenient times.

4. *Second sun-drying.*—After the storage period is over, the oil treated and stored *dol* is again exposed to sunshine for two to five days depending upon the prevailing temperature.

5. *Final splitting.*—This is also done at noon. The material is fed to the same stone mill, preferably in a warm condition at slower rate and in smaller quantities than during the preliminary splitting. During the course of this operation the seed-coats will separate, and a large portion of the unsplit material will also be split up. During splitting the mill must move comparatively slowly as otherwise a great proportion of the dhal is likely to be broken up.

6. *Sieving and winnowing.*—The split dhal is then separated and cleaned from the seed-coat by sieving and winnowing. The small broken pieces are also separated as far as possible.

7. *Treating finally with vegetable oil.*—The dhal is then finally treated with castor or gingelly oil at the rate of about 2½ lb. per 100 lb. of dhal and is ready for sale. The final oil treatment is intended to preserve the quality of dhal, prevent insect attack and make it of attractive appearance.

This method of dhal-making is rather expensive because of the use of vegetable oil at two stages and the extra labour required in double splitting. Moreover, the proportion of broken dhal is much higher. From 100 lb. of seed about 66 lb. of clean good quality dhal is obtainable. The rest is broken material and the seed-coats.

The outer covers of the seed in admixture with the small broken pieces of dhal obtained as a by-product in dhal-making is known under the name of *chuni* throughout India. It is a favourite concentrated foodstuffs for dairy cows.

Wet Method of Making Dhal

The seed collected by professional dhal makers is allowed to soak in water for about six hours either in tubs or in well constructed vats. The free water is then removed or drained away. At this stage, fine, well-sieved earth preferably of the red laterite type, is added at the rate of about 5 lb. per 100 lb. grain and well mixed. The mixture of soaked grain and moist earth is heaped up and kept in that condition for the night. Next morning, the heap is broken up and the material exposed to the sun for drying. The drying continues for a day or two according to the temperature. After thorough drying the seeds are again mixed up with a thin turbid mixture of red soil and water and heaped up for the night. Next morning they are removed and thoroughly dried. They are then sieved and winnowed to remove the earth and other impurities. The seeds are finally split into their halves in the stone mill.

Cultivators who prepare their own dhal adopt a slightly modified method which is more laborious and takes more time, but the dhal obtained is of somewhat superior quality. Instead of soaking his seed in water the cultivator prepares a thin mixture of red laterite soil and water and applies this earth solution to his seed at repeated intervals of about an hour throughout the day. Each time the earth solution is well mixed up with the seed by repeatedly turning over the heap. By this method the seeds do not absorb moisture in free water but the absorption of moisture is being effected gradually in several stages. The heap remains undisturbed throughout the night. In the morning the seed is exposed to the sun for drying and then finally split up into dhal.

The professional dhal makers allow the seeds to absorb a larger quantity of moisture and the seeds swell considerably. On drying such seed the shrinkage is great and therefore the resulting dhal assumes a marked depression in the centre. In the cultivator's method, as the soaking is gradual and according to requirements, the resulting dhal does not have so prominent a depression in the centre.

By the wet method, 100 lb. of seed yield about 80 lb. of marketable dhal. The breakage of dhal is low. The object of wetting and drying is, of course, to produce a contracting and expanding action on the seed-coat which, as a result, offers much less resistance when the seeds are being split in the mill.

Concluding Remarks

A close observation and study of the conditions under which *Cajanus cajan* is cultivated in India indicates that some of the varieties of this plant are capable of successful cultivation for seed production

in the dry parts of Ceylon. The small-scale processes of dhal-making described above are fairly simple and do not require expensive outfits. The requisite number of dry sunny days are available in the dry zones for the preparation of dhal. The local consumption of dhal in Ceylon is considerable. Under the circumstances, it is quite possible with some effort and attention to produce good quality dhal for local consumption. The crop itself is likely to prove an important rotational crop or an appropriate mixed crop in the village agriculture of this country, while the preparation of dhal offers an opportunity of being taken up as a new and profitable cottage industry in the dry zone.

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NOTICE

TWENTY-EIGHTH INDIAN SCIENCE CONGRESS BENARES

January 1941

Discussions in the Agricultural Section

The Agricultural Sectional Committee proposes to hold discussions on the following subjects during the next session of the Indian Science Congress to be held at Benares, early in January 1941. Scientific workers in India who desire to contribute papers to the above discussions are requested to communicate with the undersigned. The Rules of the Indian Science Congress Association require that authors of such contributions should be members of the Association of some category.

DISCUSSIONS

1. Drought resistance in plants.
2. The need for the exploration of wild forms for the improvement of crops.
3. Quality in crops.

Indian Institute of Science,
Hebbal P.O., Bangalore, S. India,
10*th February* 1940.

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Recorder,
Agricultural Section.

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